

# Distribution of *Salmonella* serovars in various pig production categories and risk factors for shedding in ten farrow-to-finish swine farms in western Canada.

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## Abstract

In this study, *Salmonella* prevalence, serovar distribution and risk factors for shedding were investigated in breeding, nursery, and grow-finish pigs on 10 farms in western Canada, purposely selected based on their anticipated *Salmonella*-status.

Overall, 407/1143 (36%) of samples were *Salmonella* positive; within-farm prevalence ranged from 1% to 79%. Sows, nursery and grow-finish pigs accounted for 43%, 29% and 28% of positive samples, respectively. More *Salmonella* were detected in pooled pen than individual pig samples ( $P<0.001$ ). The most common serovars were *S. Derby*, *S. Typhimurium*, var. Copenhagen, *S. Putten*, *S. Infantis*, and *S. Mbandaka*. Sows shed more *Salmonella* than nursery or grow-finisher pigs (OR 2.9,  $P<0.001$ ). Pelleted feed (OR 8.2,  $P<0.001$ ) and nose-to-nose pig contact through pens (OR 2.2,  $P=0.005$ ) were associated with increased *Salmonella* prevalence. Significant differences in serovar distribution were detected among production phases.

## Introduction

Although in North America pork is not considered a major source for human salmonellosis, *Salmonella* in pigs has become a research priority over the past decade, primarily as a result of extensive implementation of *Salmonella* surveillance or monitoring programs in Denmark and other European countries. Swine production systems can differ substantially among countries (Funk et al., 2004) and within Canada, among provinces and regions (Rajic et al., 2005). In Canada, limited research has been conducted on the epidemiology of *Salmonella* in pigs, and the research that has been done to date has focused primarily on the finishing pig. One study conducted in the province of Quebec investigated the distribution of *Salmonella* species in various pig production phases of two integrated production systems, where prevalence ranged from 17% to 66% (Letellier et al., 1999). However, no study has investigated *Salmonella* serovar distribution throughout all phases (farrow to finish) of pig production in Western Canada. Therefore, the objectives of this study were to evaluate *Salmonella* prevalence and serovar distribution in sows, nursery and grow-to-finish pigs, and risk factors for *Salmonella* shedding on 10 farrow-to-finish swine farms in Saskatchewan and Alberta.

## Materials and methods

**Farm selection:** Ten farrow-to-finish swine herds (herd size  $n>100$  sows) were purposely selected, based on their presumed *Salmonella* positive status ( $n=7$ ) or *Salmonella* negative status ( $n=3$ ). Purposeful herd selection was chosen to meet the objectives of a concurrent study evaluating diagnostic tests for *Salmonella* in pigs. Herds were presumed positive if it had clinical salmonellosis within the previous 12 months, if *Salmonella* species were identified during routine testing, or if replacement breeding stock were purchased from known *Salmonella*-positive farms. Herds were presumed negative if none of these criteria were met.

**Sample collection:** On each farm, individual samples (10 g fresh feces) were collected from each of 10 randomly selected sows. Twenty pooled samples were also taken from sows in each herd, by collecting a minimum of 5 g of feces from 5 different sows into a single container. In the grow-to-finish area,

individual samples were similarly collected from 1 pig in each of 30 different randomly selected pens. Pooled samples were also collected from each of these pens and from 30 randomly selected nursery pens. No individual fecal samples were collected from nursery pigs.

**Bacteriological Culture:** Culture for *Salmonella* was performed by the Agri-Food Laboratories Branch, Alberta Agriculture and Rural Development. In brief, 10 g of feces were inoculated into buffered peptone water (BPW) at 35°C for 20-24 hrs. This was then inoculated into Rappaport Vassiliadis (RV) and tetrathionate (TT) broths at either 42°C (RV) or 35°C (TT) for 22-24 hrs. RV and TT were then streaked onto XLT4 and Rambach (RAM) selective agar plates at 35°C for 24 and 48 hrs. TT was also inoculated onto a modified semi-solid RV (MSRV) plate at 42°C for 20 – 24 hrs. Growths that occurred on MSRV were streaked to XLT4 and RAM at 35°C and read at 24, 48 and 72 hrs. Suspect colonies were screened using biochemical reactions and sero-agglutination. Isolates were serotyped at the OIE Reference Laboratory for Salmonellosis, Laboratory for Foodborne Zoonoses, Public Health Agency of Canada, Guelph, ON.

**Data collection:** During sampling, the following information was recorded: pen and pig information; sex and age of each individual pig sampled; number of pigs in pen, area and pig density; floor and wall type, and cleanliness of each pen; feed type and feeding method; nose-to-nose contact between pens, and feces characteristics.

**Statistical Analysis:** Generalized linear mixed models, with a random intercept to account for clustering of individual and pen samples within herd, using a logit link function, binomial distribution and an exchangeable correlation structure. Risk factor analysis was limited to pooled fecal samples because individual samples were only available from two of three phases.

## Results

**Salmonella prevalence:** *Salmonella* was isolated from all 10 study farms. Based on total numbers of positive samples, prevalence within presumed-negative herds ranged from 20 to 56%, while prevalence within presumed-positive herds ranged from 2 to 79%. Across all production phases there were 407/1143 (35.6%) positive fecal samples. Prevalence was highest in the breeding sows, with 38% (38/99) and 51% (102/200) of individual and pooled samples, respectively, positive for *Salmonella*. In the grow-finish population, 25% (73/294) of the individual samples and 38% (113/295) of the pooled pen samples tested positive. In the nursery, 32% (81/255) of all pooled pen samples were positive. The occurrence of *Salmonella* positive samples varied significantly among all production phases for the pooled samples ( $P<0.001$ ) and between the breeding sows and grow-finish population for the individual samples ( $P=0.002$ ).

**Risk factors for shedding Salmonella:** The variables “pelleted feed”, “production phase”, and “nose-to-nose contact” were the predictors remaining significant ( $P<0.05$ ) in the final multivariable model. Sows were 2.3 (CI<sub>OR</sub> 1.5, 3.7) times more likely to shed *Salmonella* than grow-finish pigs, and 4.0 (CI<sub>OR</sub> 2.4, 6.8) times more likely to shed than nursery pigs; grow-finishers were 1.7 (CI<sub>OR</sub> 1.1, 2.8) times more likely to shed *Salmonella* than nursery pigs. Pooled samples from pens that received pelleted feed were 8.2 (CI<sub>OR</sub> 3.2, 20.6) times more likely to be positive than samples from pens with meal feed. Pens allowing for nose-to-nose contact among pigs were 2.2 (CI<sub>OR</sub> 1.3, 4.0) times more likely to be positive than pens without such contact.

**Salmonella recovery from pooled vs. individual samples:** Overall, *Salmonella* was isolated from 38% (113/295) of pooled grow-finish samples and 25% (73/294) of individual samples. The odds of *Salmonella* recovery from grow-finishers were 2.9 times (CI<sub>OR</sub> 1.8, 4.5;  $P<0.001$ ) higher from pooled than individual samples.

**Salmonella serovar distribution:** Nineteen distinct serovars were identified. Multiple serovars (2-8) were detected on all but 1 farm. Fewer serovars were detected in individual samples (7 and 8 typed serovars, for sows and grow-finish, respectively) than in pooled samples (13, 12 and 12 typed serovars, for sows, grow-finish and nursery, respectively). The 5 most common serovars were *S. Derby* (28.5%), *S. Typhimurium*, var. Copenhagen (19.4%), *S. Putten* (11.7%), *S. Infantis* (6.7%), and *S. Mbandaka* (6.2%).

The production phase serovar distributions were compared for the 5 most prevalent serovars, with the exception of *S. Mbandaka*. Since this serovar was not isolated from the breeding herd, this comparison

was limited to nursery pigs and grow-finishers production phases. Significant pair-wise contrasts are presented in Table 1.

Table 1. Differences in *Salmonella* serovar distribution between production phases on 10 farrow-to-finish pig farms in Alberta and Saskatchewan

Serovar	Contrast	OR	CI <sub>ORlower</sub>	CI <sub>ORupper</sub>
<i>S. Derby</i>	grow-finish vs. nursery	10.2	4.2	24.9
	grow-finish vs. sows	1.5	0.9	2.5
	sows vs. nursery	6.7	2.6	16.9
<i>S. Infantis</i>	sows vs. nursery	3.1	0.9	10.8
<i>S. Putten</i>	sows vs. nursery	3.2	1.2	9
<i>S. Typhimurium</i> var. Copenhagen	nursery vs. grow-finish	3.0	1.4	6.4
	sows vs. grow-finish	3.3	1.7	6.4
	nursery vs. grow-finish	4.4	1.7	11.3

## Discussion

Existing research on the epidemiology of *Salmonella* in pigs has focused primarily on finishing pigs due to their proximity to the consumer. Still, pigs of other ages can play an important role in the maintenance and dissemination of *Salmonella* on-farm, as well as contribute to food safety issues themselves. The current study parallels previous studies where sows were more at risk for shedding *Salmonella* than both nursery and grow-finish pigs (Funk et al., 2004; Nollet et al., 2005). Cull sows are usually shipped to slaughter immediately after weaning, when increased shedding has been observed (Nollet et al., 2005). Additionally, transport and lairage practices may contribute to increased shedding of *Salmonella* by sows immediately prior to slaughter (Larsen et al., 2004). For these reasons, potential control efforts should be placed on this population both on-farm and at slaughter to reduce the on-farm *Salmonella* reservoir as well as minimize potential food safety risks.

The use of pelleted feed and nose-to-nose pig contact through pens were two other significant risk factors detected in this study. Other researchers have also reported strong associations between the use of pelleted feed and farm *Salmonella* status (Kranker et al., 2001; Lo Fo Wong et al., 2004); efforts to reduce *Salmonella* at the farm level might therefore include changing feed to coarser-grind rations. Nose-to-nose contact between pigs through pens is a less likely target for intervention, since this is a feature inherent to barn. However, consideration of the possibility of transmission of *Salmonella* and other important pathogens between pens and production units should be taken into consideration when designing and building new barns.

One-time sampling of individual pig feces (vs. repeated or pooled samples) has been identified, among other reasons, for poor sensitivity of *Salmonella* culture (Funk, 2003). Similarly, in our study, more positives were found in pooled pen samples than from individual pigs. Furthermore, more positive farms were identified when sampling pigs from all production phases. The use of pooled pen samples, from all phases of pig production, is recommended as a more reliable means of accurately establishing the prevalence of *Salmonella* in swine herds.

Significant differences were observed in serovar prevalence between production phases. Sampling only finisher pigs would not have detected the full range of serovars present on these farms. An understanding of serovar type and distribution is important since certain serological tests, such as the Danish-mix ELISA, detect antibodies against serogroups B, C1 and D1 only (Rajic et al., 2005). Serological response to serovars such as *S. Mbandaka*, or *S. Putten*, would not have been detected by this ELISA. The changes in serovar distribution as pigs progress through the production cycle presents a

challenge to *Salmonella* surveillance and control efforts which utilize serological tools only; cost-effective complementary bacteriologic testing of samples from all levels of pig production is necessary for accurate evaluation of *Salmonella* status in swine herds

This study indicates that the breeding herd plays an important role in the persistence of *Salmonella* infection within pig herds. Molecular fingerprinting methods are needed in order to confirm clonal spread of *Salmonella* from sows to other production phases within these herds. In summary, this study has contributed to future surveillance and control efforts by providing important insight into the on-farm epidemiology of *Salmonella* in western Canada.

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